Report IGM-85-107-198

STRESS ANALYSIS OF THE BRIDGE EXPANSION JOINT-MODEL ZT2A

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STRESS ANALYSIS OF THE BRIDGE EXPANSION JOINT-MODEL ZT2A

1.0 INTRODUCTION

This study aims the evaluation of stress level into the bridge expansion joint (model ZT2A) according to the criteria of the Ontario Highway Bridge Design Code Loadings (OHBDCL) given in Appendix A.

The geometry and arrangement of the bridge expansion joint is shown in fig. 1.:

> The rail (2"h x 1"w x 1/4"t) which supports the neoprene seal is welded to a 3"x3"x3/8" steel angle. This latter is properly anchored in the concrete by a system of plates and bars welded to the steel angle.

The stresses are evaluated by using the finite element method. Conservatively, a 2-D plane stress model is used to compute the behavior of the assembly in response to the applied loads. The appropriate finite element model used to analyse the bridge expansion joint is shown in fig. 2. The bending load effect on the joint, in its axial plane, will be added to the finite element results by hand calculations. The stress results are presented in section 5.

N.B. Units of results are in the British system. Those given in parentheses are in the SI system.

2.0 EVALUATION OF LOADS

The loads on the finite element model are evaluated according to the OHBDCL specifications (see Appendix A).

The specified wheel load is 22480 lb (100 kN). As required, a live load factor of 1.4 and a dynamic allowance factor of 1.5 are applied. The total load is then:

$$F = 22480 \times 1.4 \times 1.5 = 47210 \text{ lb.}$$

The specified wheel load is distributed over a surface of

$$Ac = 23\ 5/8" \times 9\ 13/16" = 231.8 \text{ in}^2.$$

with the 9 13/16" dimension being measured along the highway.

The equivalent pressure corresponding to the total load is:

$$P = 47210/231.8 = 203 \text{ psi } (1400 \text{ kN/mm}^2)$$

According to the specifications, the appropriate portion of the load shall be applied onto the joint assembly in order to produce maximum force effects. Furthermore, any portion of the wheel load over the joint gap shall be applied as a concentrated load on one edge of the rail (near the gap) but at an angle not exceeding 45 degrees.

Based on the manufacturer's data, a maximum gap of 4 in. between the two rails of the bridge expansion joint is assumed at the minimum temperature of -22 F (-30 C) as shown on fig. 3.

The worst case is assumed when part of the wheel is over one rail of the expansion joint, just before touching the second rail, considering at the same time that the two rails are distant by the maximum possible gap value.

To satisfy the above requirements, the two following loads are computed:

-Load applied over the rail: Fr

A = 23.625"x(4"+1"+0.25") = 124.03 in2

Fr = 203 psix124.03 in2 = 25180 lb.

As required, this load is applied at the nearest point of the rail where the tangent to its profile is at 45 degree. Furthermore, as shown on fig. 2 and 4, the load is conservatively assumed to act vertically (producing a greater bending effect) on the top of the rail.

-Load applied over the concrete: Fc

Fc = 47210-25180 = 22030 lb.

This load is applied at the midline of the area of the wheel over the concrete, as shown on fig. 4.

-Horizontal Load

N.B.: Since all the specified horizontal load will be overtaken by the concrete rather than by the rail, due to the actual arrangement of the bridge expansion joint (the rail being under the road level), it is assumed that the horizontal load produces negligible stress into the rail. Therefore, the horizontal load is not considered in this analysis.

3.0 MATERIAL PROPERTIES

3.1 Rail and Steel Angle (see Fig. 1)

The material of the rail is A715 type 6. The properties used for both the rail and the steel angle are:

Elastic modulus= 30x10**6 psi.
Poisson ratio= 0.3
Minimum yield strength= 50000 psi.

Appendix B summarizes the material properties of the rail.

3.2 Concrete

The material properties of the concrete are taken from Ref. 1.:

Elastic modulus= 15x10**6 psi.
Poisson ratio= 0.2

4.0 FINITE ELEMENT MODEL

The finite element model used for the stress analysis is shown on fig. 2 and fig. 4. The displacement function of the elements is linear. Combination of quadrilateral and triangular elements are used to create an appropriate numerical model. Elements are concentrated in particular area where stresses are expected to be worst.

The following assumptions are made:

-An elastic analysis is valid.

-Materials are homogeneous for rail, welds, steel angle and concrete.

-An equivalent continuous weld of 1/10" is used to replace the actual weld of 1/4" x 2" long à 12" c/c at the bottom of the rail (see fig. 1).

-A 2-D plane stress analytical model is conservatively used to evaluate the stresses. Distributed loads Fr' and Fc' are applied over the unit thickness of the model. These loads are computed from loads Fr and Fc as:

Fr'= Fr/23.625" = 25180/23.625 = 1065.8 lb/in

Fc'= Fc/23.625" = 22030/23.625 = 932.5 lb/in

-The 8" concrete road slab is assumed simply supported in the horizontal and vertical directions as shown in fig. 4.

5.0 STRESS_ANALYSIS_RESULTS

Two failure theories have been used in this report: the maximum normal and shear stresses.

Stresses computed in the model are compared to the following stress limits:

-Stress limit for tensile or compressive stress:

Sy = 50000 psi.

-Stress limit for shear stress:

Ssy = 0.5xSy = 25000 psi.

Principal normal stresses and shear stresses, evaluated by the finite element program, are summarized in fig. 6, fig. 7 and fig. 8 respectively.

Furthermore, relevant pages of the program output for elements subject to maximum stresses are given in Appendix C.

Evaluation_of_the_Bending_Stress_in_the_Axial_Plane_of_the_Rail:

The concrete slab is assumed to be supported by two beams distant of 100" c/c as shown on fig. 1.

Conservatively, the beam theory is used to evaluate the bending effect of the total wheel load instead of the plate theory (stresses being higher in the beam theory).
The beam model used to represent the assembly is:

-A rectangular beam of 24"x8" (part of the concrete slab)
-The rail and the steel angle (fig. 1) are bound up to the concrete slab
-The beam is simply supported at both ends (beam length = 100")
-The total wheel load is F = 47210 lb. This load is applied at the beam centre.

Therefore, the maximum bending stress in the axial direction of the rail is (Ref. 2, case 1e):

Sz = -M x c /I

M = 47210 x 100 /4 = 1180250 lb-in.

c = 8/2 = 4"

I = 24 x (8)**3 /12 = 1024 in4.
(neglecting the inertia of the rail)

Sz = -1180250 x 4 /1024 = -4610 psi.

The combination of this bending stress with other finite element results provides the total state of stress at the two worst locations of the rail. These points, shown in fig. 6 and fig. 7, are revealed by the finite element analysis. Stresses computed at these points are also given in Appendix C.

It should be noted that any stress distribution presented in fig. 6 to fig. 8 is obtained from the computed stresses at the centre of gravity of each element. On the other hand, the stresses presented in the Appendix C, for the quadrilateral elements, are evaluated at Gaussian points of each element. Since some of these points are closer to the surface of the part than for the centre of gravity of the element, stresses may be higher than those given in fig. 6 to fig. 8.
In any case, the highest value of maximum stresses is used in this report.

Point_of_Maximum_Tensile_Stress:

The total principal stresses are
(see fig. 6 and results for element 69, Appendix C):

S1 = 30650 psi.
S2 = 35 psi.
S3 = -4610 psi.

The maximum shear stress is therefore,

Ss = (30650 - (-4610))/2 = 17630 psi.

Since S1 < Sy and Ss < Ssy ,

the design is acceptable.

Point_of_Maximum_Compressive_Stress:

The total principal stresses are
(see fig. 7 and results for element 98, Appendix C):

S1 = -5100 psi.
S2 = -37365 psi.

S3 = Sz = -4610 psi.

The maximum shear stress is therefore,

Ss = (-37365 - (-4610))/2 = -16380 psi.

Since $|S2| < Sy$ and $|Ss| < Ssy$,

the design is acceptable.

6.0 SUMMARY OF RESULTS

Category of Stress	Maximum Stress (psi)	Stress LImit (psi)	Location
tension	30650 (210)	50000 (345)	top of rail (see fig. 6)
compression	-37365 (-258)	50000 (345)	top of rail (see fig. 7)
shear	17630 (120)	25000 (172.5)	top of rail (see fig. 8)

N.B. Numbers in brackets are in MegaPascal (MPa).

The resulting safety factor is n=50000/37365=1.35

7.0 CONCLUSION

The bridge expansion joint model ZT2A meets all the requirements of the technical specifications of the Ontario Highway Bridge Design Code Loadings (see Appendix A).

Even if the technical specs use a severe wheel load amplification of 2.1 = * 1.4 (live load factor) x 1.5 (dynamic load allowance) §, the analysis shows an extra safety factor of n=1.35.

The vertical wheel load is the only load considered in the present analysis since the specified horizontal load has no significant stress effect on the rail of the bridge expansion joint.

Any other stresses that can result from the manufacturing process or from the installation of the bridge expansion joint are excluded from this analysis.

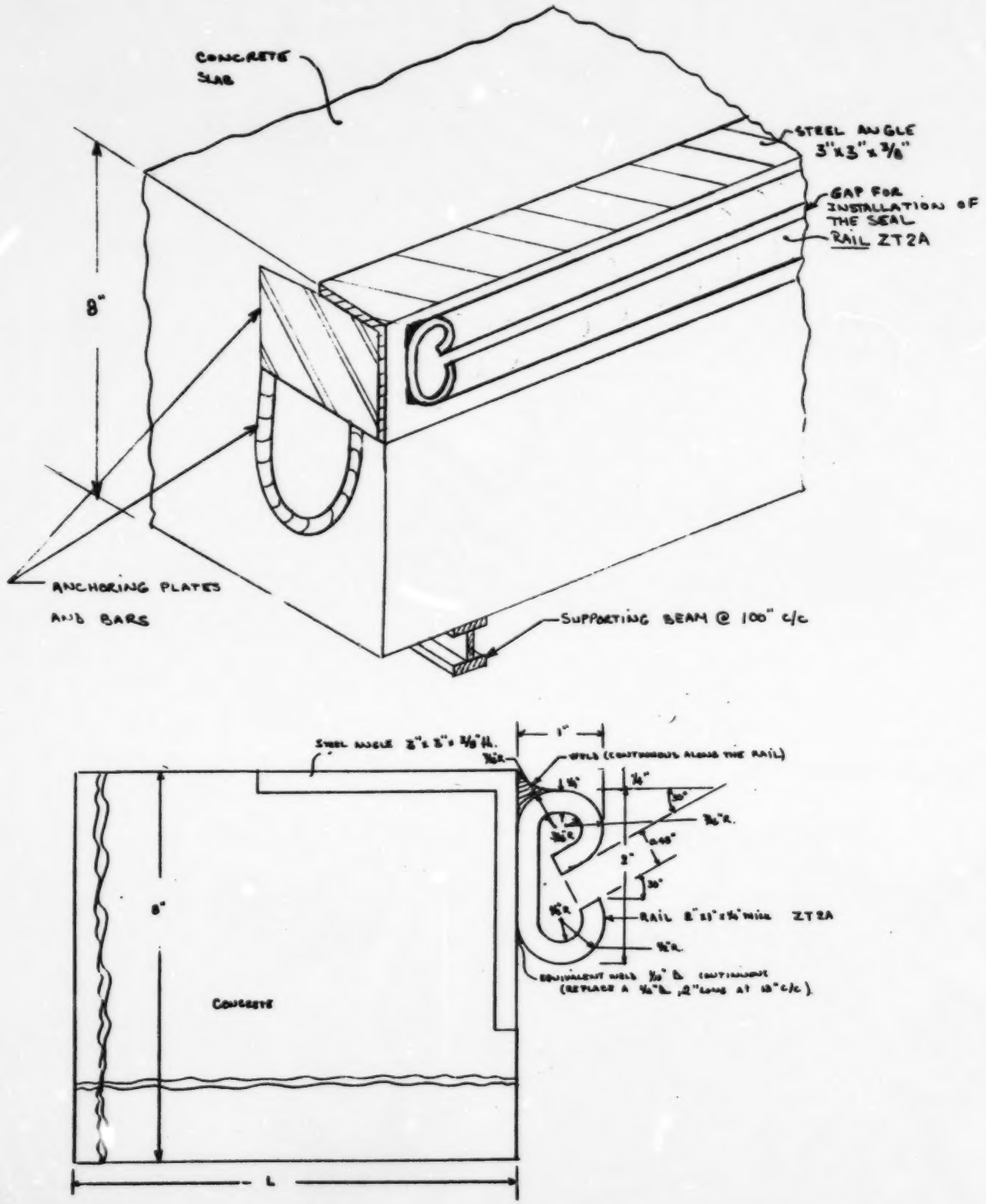


FIG. 1: GEOMETRY AND ARRANGEMENT OF THE BRIDGE EXPANSION JOINT - MODEL ZT2A
(RAIL : 2" x 1" x 1/2" THICK)

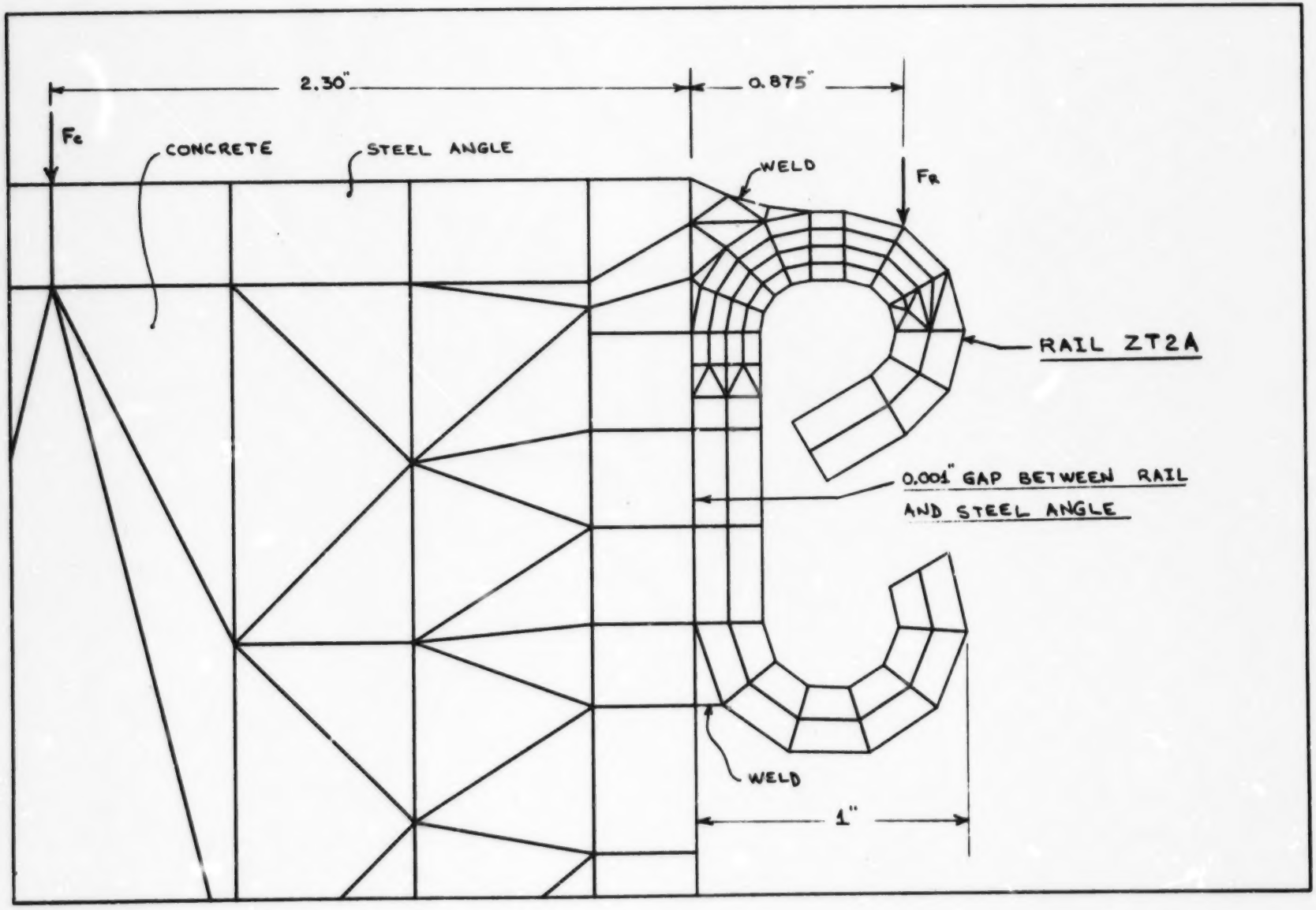


FIG. 2: FINITE ELEMENT MODEL (PARTIAL VIEW) OF THE BRIDGE EXPANSION JOINT - MODEL ZT2A

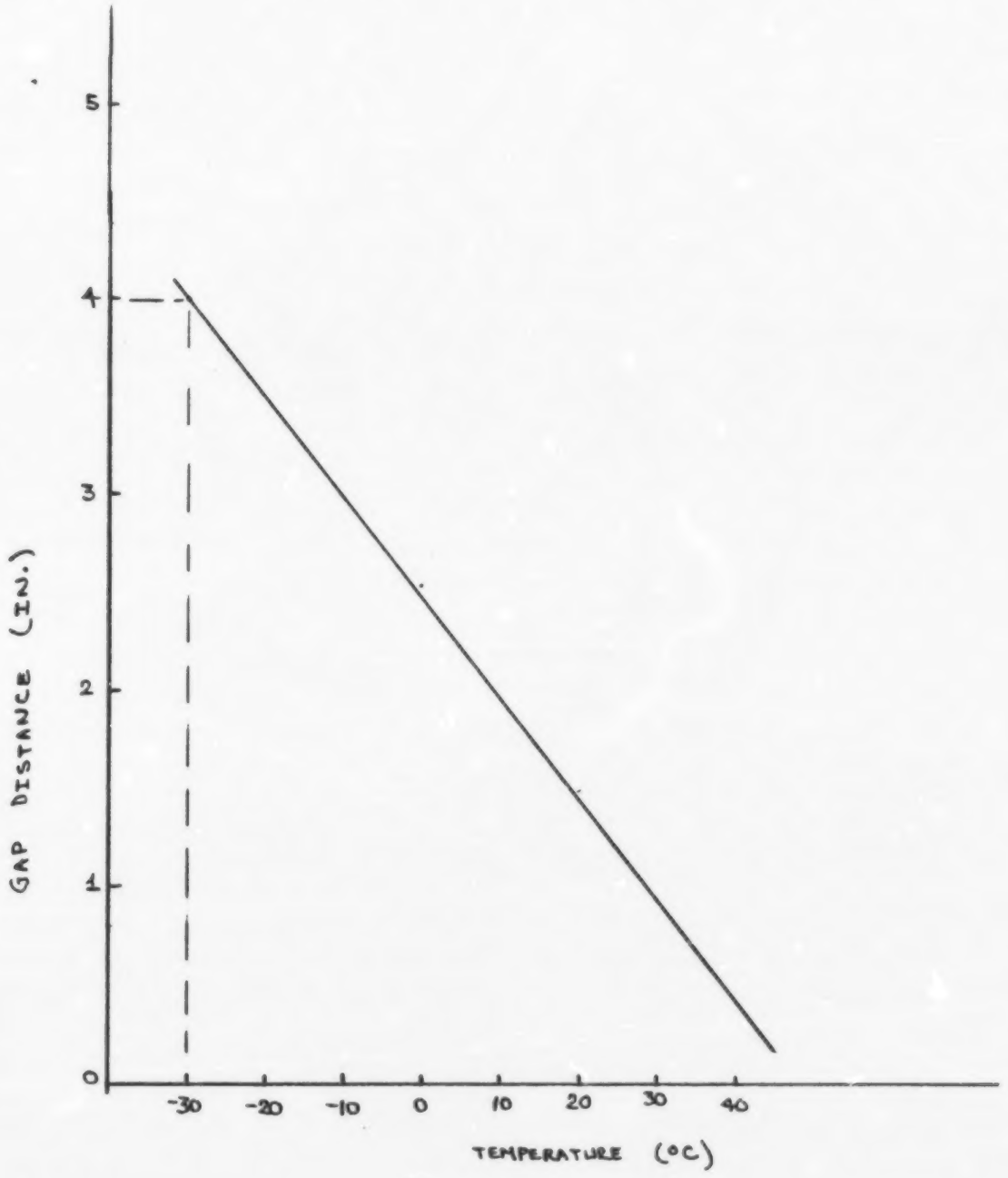
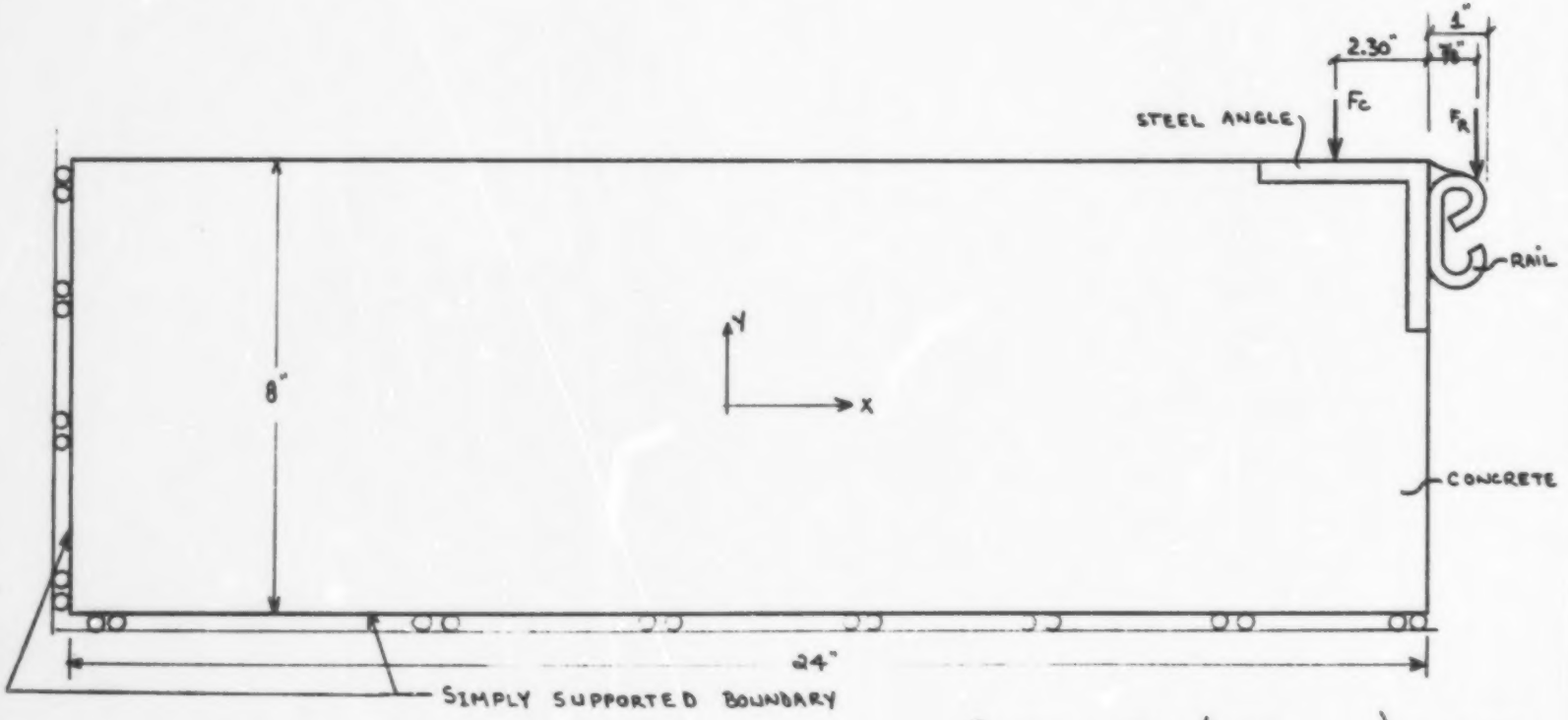


FIG. 3: GAP DISTANCE BETWEEN THE TWO RAILS OF THE EXPANSION JOINT ACCORDING THE TEMPERATURE



$E_{STEEL} = 30 \times 10^6$ PSI $\quad \nu_{STEEL} = 0.3$

$E_{CONCRETE} = 15 \times 10^6$ PSI $\quad \nu_{CONCRETE} = 0.2$

$F_R = 1065.8$ LB/IN-THICKNESS

$F_c = 932.5$ LB/IN-THICKNESS

FIG. 4 : BOUNDARY CONDITIONS APPLIED TO THE MATHEMATICAL MODEL

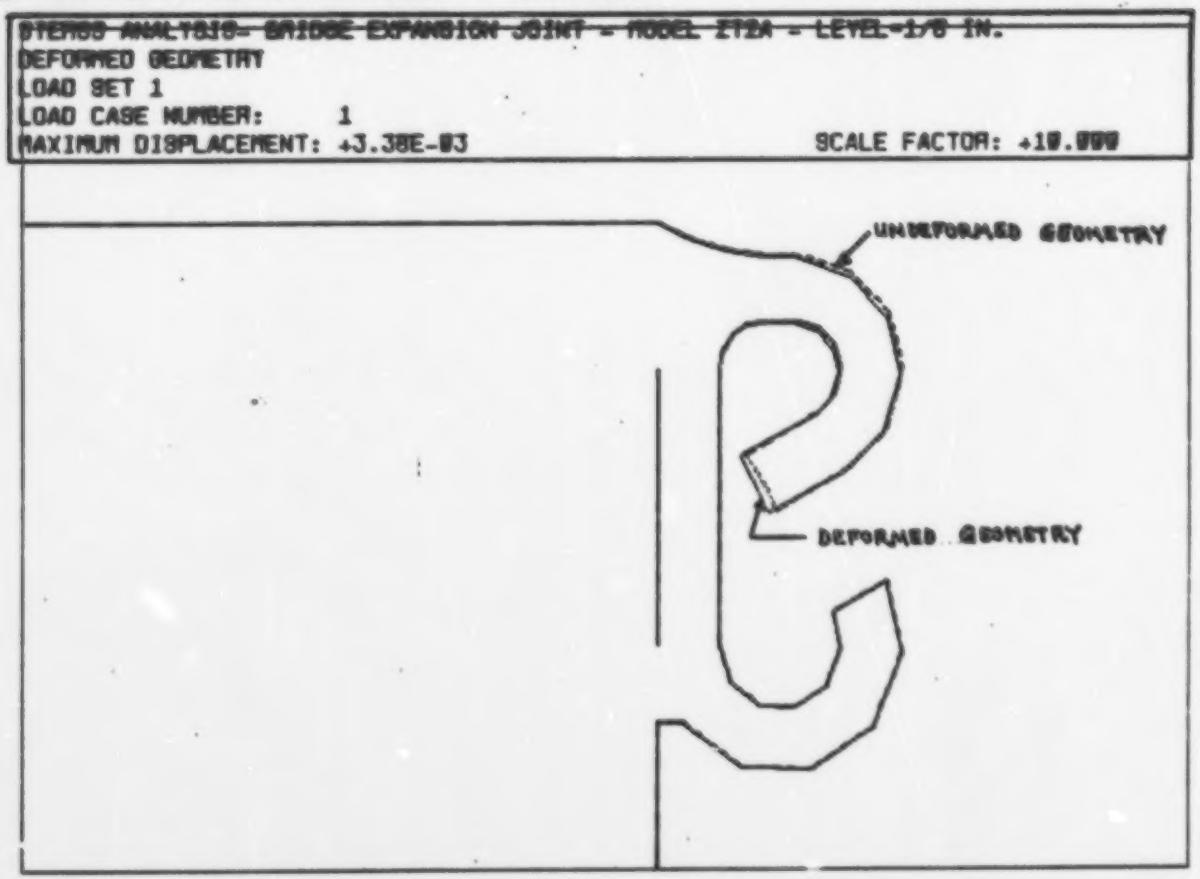


FIG. 5: BRIDGE EXPANSION JOINT MODEL ZT2A- DISPLACEMENT

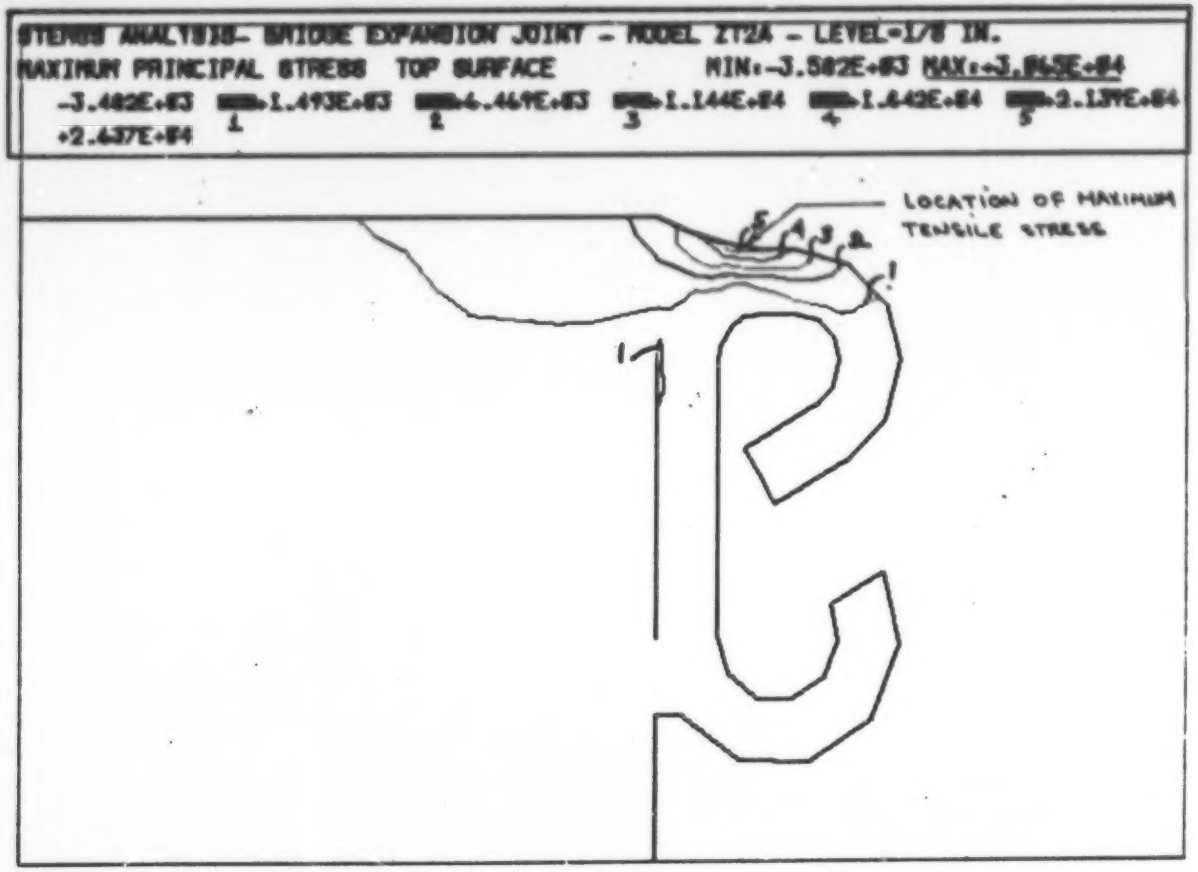


FIG. 6: BRIDGE EXPANSION JOINT MODEL ZT2A- MAXIMUM PRINCIPAL STRESS

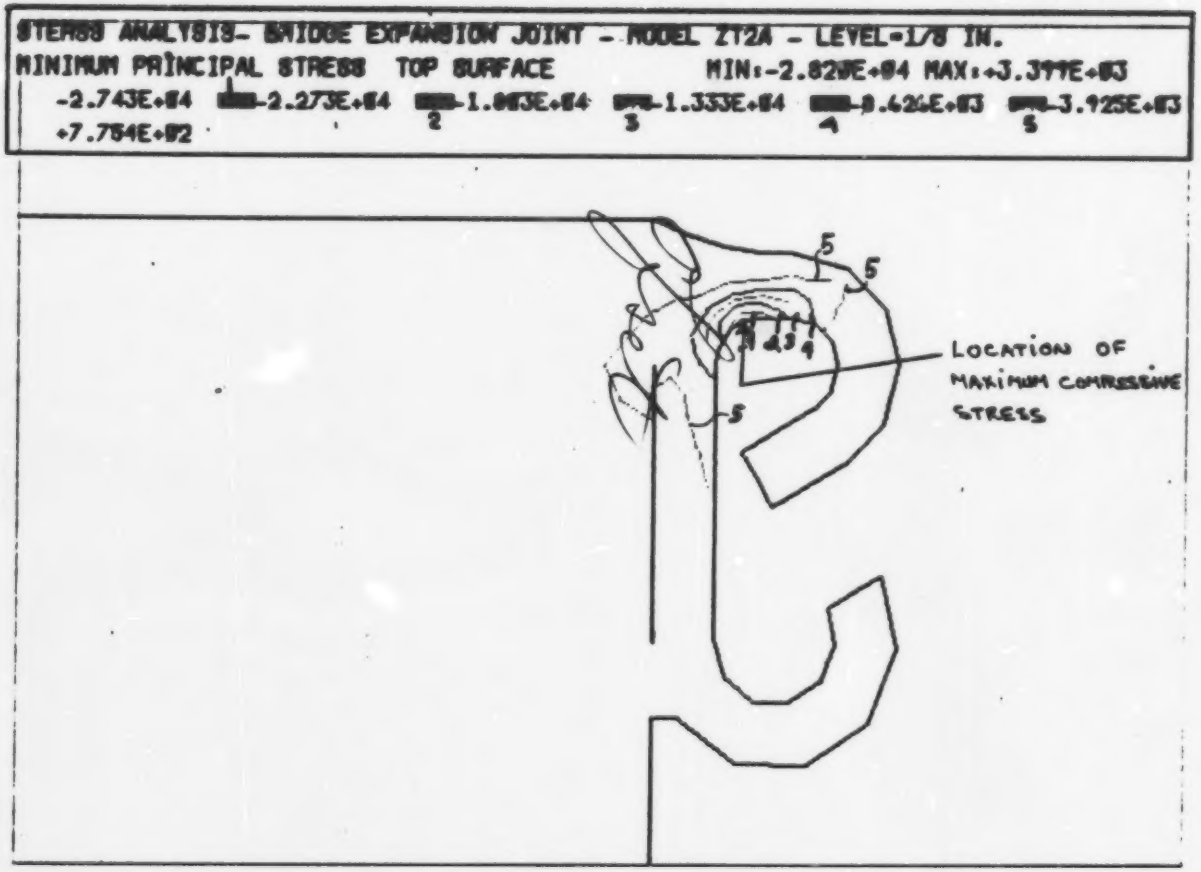


FIG. 7: BRIDGE EXPANSION JOINT MODEL ZT2A- MINIMUM PRINCIPAL STRESS

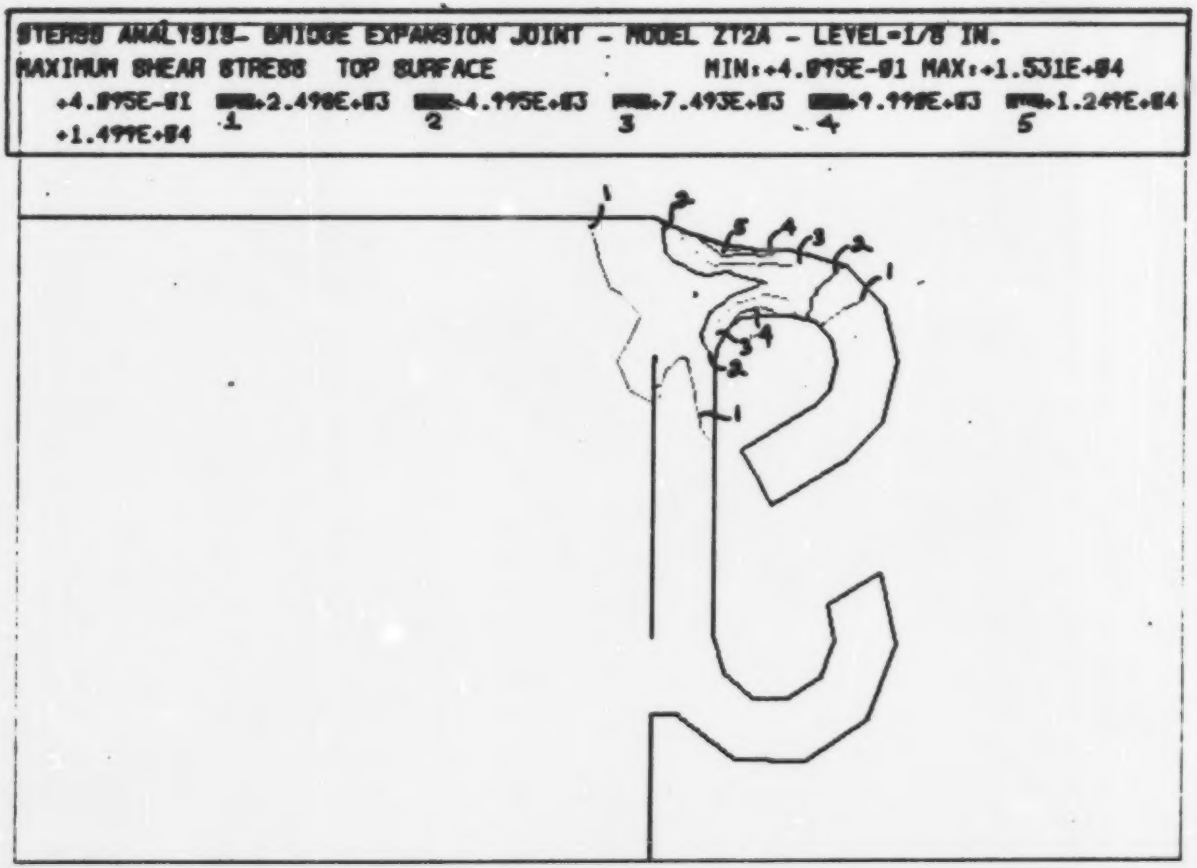


FIG. 8: BRIDGE EXPANSION JOINT MODEL ZT2A- MAXIMUM SHEAR STRESS

REFERENCES

[1]... CIVIL ENGINEER'S REFERENCE BOOK
3rd ed., L. S. Blake, Table 2.1, p. 2-12

[2]... FORMULAS FOR STRESS AND STRAIN
5th ed., R. J. Roark and W. C. Young

APPENDIX A

Technical Specifications of the

Ontario Highway Bridge Design Code Loadings (OHBDCL)

Vertical Load

Wheel Load	- 100 kN (22480 LB)
Contact Area	- 600 mm (perpendicular to highway) (23.62") x 250 mm (along highway) (9.84")
Live Load Factor	- 1.4
Dynamic Load Allowance	- 1.5

The appropriate portion of the load shall be applied to the joint to produce maximum force effects. The loading shall be applied as a factored distributed load of 14.00kN/m^2 (292 PSF). Any portion of the wheel load over the joint gap shall be applied as a concentrated load at one edge of the gap. Load distribution at an angle not exceeding 45° is permissible within the joint components where justified by the continuity and rigidity of the joint.

Horizontal Load

Horizontal force - 60 kN/m (3426 LB/FT)
Live Load Factor - 1.4

A factored force of 84 kN/m (4800 LB/FT) shall be applied at the level of the road surface in combination with forces which result from the movement of the joint to produce maximum force effects.

APPENDIX B

Material Data

Dofascoloy F

Description

The Dofascoloy F series are fully killed high strength low alloy steels with excellent formability and weldability. These steels are available in minimum yield strength grades from 45,000 to 80,000 psi.

Forms Available

H.R. sheet & coil C.R. sheet & coil Galvanized sheet & coil H.R. plate

Compatible Society Specs

A715 type 6

Chemical Composition

All grades	C max	Mn max	P max	S max	Si max	Cb min.
	.15	1.65	.025	.035	.90	.005

Mechanical Properties

Grade	Yield point min. psi	Tensile Strength min. psi	% Elongation in 2"	% Elongation in 8"
45F	45,000	55,000	24.0	19.0
50F	50,000	60,000	24.0	19.0
60F	60,000	70,000	22.0	18.0
70F	70,000	80,000	20.0	17.0
80F	80,000	90,000	18.0	16.0

NOTE: See basic guide to selection of High Strength Low Alloy Steels page 3

Formability

Cold Forming

Grade	Recommended inside bend radius to material thickness (t) Thickness (inches) Up to .125	>.125-.250	>.250-.500
45F	1t	1t	1½t
50F	1t	1t	2t
60F	1½t	2t	2½t
70F	2t	2½t	3t
80F	2½t	3t	3½t

Note: Dofascoloy F series has equal formability in all directions.

Notch Toughness

Typical Charpy 'V' notch transition temperature

Grade	Energy	Up to .230"
50F	15 ft. lbs. (longitudinal)	−50°F

Welding

The Dofascoloy F series of high strength low alloy steels offer excellent weldability by all the various arc welding methods, e.g. shielded metal arc, flux core arc, etc. Low hydrogen filler metals are recommended, the choice being dependant on the strength level of the base plate. No preheating or post heat treatment is necessary.

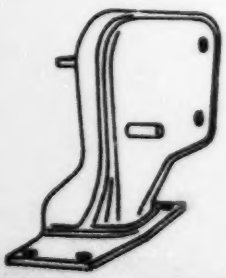
Dofascoloy F series are also suitable for welding by all the electrical resistance methods.

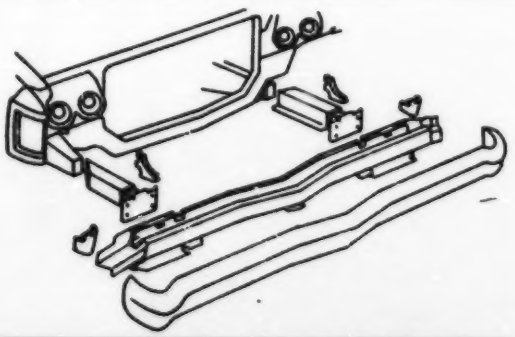
Atmospheric Corrosion Resistance

Atmospheric corrosion resistance is equivalent to that of plain carbon steel (Less than .02% Cu.).

Typical Applications

Primary applications intended for automotive components, railroad and agricultural equipment, requiring excellent formability.





	Dofascoloy #1	Dofascoloy P	Dofascoloy W	Dofascoloy F	Dofascoloy MV	Dofascoloy M
Description	Fully-killed, high strength low alloy weathering steel with good notch toughness.	Fully-killed, high strength low alloy weathering steel with good weldability and forming characteristics.	High strength low alloy steel with good formability and weldability at low cost.	Fully-killed, high strength low alloy steel with excellent form-ability and weld-ability.	Fully-killed high strength low alloy steel, intended primarily for welded construction.	Fully-killed, high strength low alloy steel, intended primarily for riveted or bolted construction.
Strength	Min. Yield point: 50,000 psi Min. Ultimate: 70,000 psi	Min. Yield point: 50,000 psi Min. Ultimate: 70,000 psi	Strength levels available Min. Yield point: 45,000-80,000 psi Min. Ultimate: 60,000-95,000 psi	Strength levels available Min. Yield point: 50,000-80,000 psi Min. Ultimate: 60,000-90,000 psi	Min. Yield point: 50,000 psi Min. Ultimate 70,000 psi	Min. Yield point: 50,000 psi Min. Ultimate 70,000 psi
Formability*	Good	Good	Good*	Excellent*	Good	Fair
Atmospheric Corrosion Resistance	At least Four times plain carbon steel	At least Four times plain carbon steel	Equal to plain carbon steel	Equal to plain carbon steel	At least Two times plain carbon steel	At least Two times plain carbon steel
Weldability	Readily weldable by filler metal and resis-tance methods.	Readily weldable by filler metal and resis-tance methods.	Readily weldable by filler metal and resis-tance methods.	Readily weldable by filler metal and resis-tance methods.	Readily weldable by filler metal and resis-tance methods.	Not recommended for welding applications.
Notch Toughness	Excellent	Poor	Good	Excellent	Very good	Poor.

Note: (1)
All products specified to be furnished in coils are produced to the same strength level practices as cut-length products. However, recognition must be given to the fact, that, testing within the body of the coil cannot be performed by the producer and that some portions of coils could be below the specified minimums.

*It should be noted that formability is relative, and will decrease as strength level increases.

Note: (2)
Plain carbon steels refer to steels containing less than .02% residual copper.

Note: (3)
Mechanical properties are based on tests in the longitudinal direction.

Effective date June 1, 1978

APPENDIX C

Relevant Pages of the Computer Program Output

(Finite Element Analysis)

APPLICON IFAD VERSION 2.0 26-FEB-85 11:
PROBLEM NAME = USER:[GERALD]ZTECHMOD;
STERSS ANALYSIS- BRIDGE EXPANSION JOINT - MODEL ZT2A - LEVEL=1/8 IN.

**** ELEMENT MATERIAL TABLES ****

IMAT	MTYPE	DENM	NTEMP
1	ISOTROPIC	1.0000E+00	1

TEMP	E	G	NU	ALPHA
0.00	3.0000E+07	0.0000E+00	3.0000E-01	0.0000E+00 ← STEEL

IMAT	MTYPE	DENM	NTEMP
2	ISOTROPIC	1.0000E+00	1

TEMP	E	G	NU	ALPHA
0.00	1.5000E+07	0.0000E+00	2.0000E-01	0.0000E+00 ← CONCRETE

APPLICON IFAD VERSION 2.0 26-FEB-85 11:07
PROBLEM NAME = USER:[GERALD]ZTECHMOD;
STERSS ANALYSIS- BRIDGE EXPANSION JOINT - MODEL ZT2A - LEVEL=1/8 IN.

********* LOAD CASE 1 *********
LOAD SET 1

**** NODE LOADS ****

NODE	FX	FY	FZ	MX	MY	MZ
19	0.0000E+00	-1.0658E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
87	0.0000E+00	-9.3250E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

********** END OF INPUT DISPLAY **********

APPLIED LOADS

PROBLEM NAME - [illegible]
STERSS ANALYSIS- BRIDGE EXPANSION JOINT - MODEL ZT2A - LEVEL=1/8 IN.

OUTPUT FOR LOAD CASE 1
LOAD SET 1

PLANE STRESS -- 3 NODED, CONSTANT STRAIN TRIANGLE

ELEMENT 68	LOC 1	ELEMENT 69	LOC 1	ELEMENT 89	LC
X	4.54779E-02	X	3.31084E-01	X	2.08333E-0
Y	2.050	Y	1.996	Y	1.40
SEFF	11201.735	SEFF	30631.586	SEFF	2494.5
SXX	10699.533	SXX	28031.834	SXX	617.0
SYY	260.838	SYY	2649.172	SYY	1069.6
SXY	-2138.665	SXY	-8558.687	SXY	-1336.4
PRINCIPAL STRESSES S1	11120.707	S1	30648.050	S1	2198.7
PRINCIPAL STRESSES S2	-160.335	S2	32.955	S2	-512.1
EPE	2.35578E-02	EPE	6.54563E-02	EPE	3.54938E-0
EKE	0.0	EKE	0.0	EKE	0.

ELEMENT 92	LOC 1	ELEMENT 93	LOC 1	ELEMENT 94	LC
X	1.45833E-01	X	1.87500E-01	X	2.29167E-0
Y	1.405	Y	1.366	Y	1.40
SEFF	3977.459	SEFF	5543.938	SEFF	6677.82
SXX	128.045	SXX	159.410	SXX	305.3
SYY	-3487.479	SYY	-5442.808	SYY	-6479.6
SXY	-1031.943	SXY	269.594	SXY	-422.4
S1	401.848	S1	172.354	S1	331.5
S2	-3761.281	S2	-5455.751	S2	-6505.8
EPE	9.35561E-04	EPE	3.73338E-03	EPE	2.68886E-0
EKE	0.0	EKE	0.0	EKE	0.

ELEMENT 135	LOC 1	ELEMENT 136	LOC 1	ELEMENT 137	LC
X	7.55761E-01	X	7.65430E-01	X	9.38795E-0
Y	1.619	Y	1.660	Y	1.6
SEFF	1215.948	SEFF	892.020	SEFF	413.2
SXX	316.415	SXX	259.459	SXX	41.2
SYY	677.500	SYY	42.795	SYY	429.1
SXY	-614.756	SXY	-495.867	SXY	29.2
S1	1137.676	S1	658.690	S1	431.3
S2	-143.761	S2	-356.435	S2	39.0
EPE	6.89994E-05	EPE	1.82757E-05	EPE	4.04471E-0
EKE	0.0	EKE	0.0	EKE	0.

L VEL=1/8 IN.

AL

LOC 4	ELEMENT 88	LOC 1	LOC 2	LOC 3	LOC 4
9.5845E-02	X	2.64156E-02	9.85844E-02	2.64156E-02	9.85844E-02
1.134	Y	1.233	1.233	1.301	1.301
3397.788	SEFF	606.832	2277.231	1677.367	2826.277
-215.416	SXX	546.914	-156.637	366.891	-336.660
3068.557	SYY	30.353	-2314.815	-23.654	-2368.822
-956.301	SXY	-168.137	-234.851	-943.347	-1010.061
75.458	S1	596.819	-131.376	1134.964	79.965
3359.430	S2	-19.553	-2340.075	-791.728	-2785.447
	EPE	8.88565E-04			
	EKE	0.0			

LOC 4	ELEMENT 96	LOC 1	LOC 2	LOC 3	LOC 4
6.8379E-01	X	6.55876E-01	6.41647E-01	5.87520E-01	5.83707E-01
1.721	Y	1.774	1.742	1.793	1.758
2996.762	SEFF	7635.239	11720.122	11582.331	15045.744
2597.130	SXX	-7590.661	-12530.507	-9168.127	-14391.588
639.529	SYY	-2.118	-2016.357	1691.967	-17.704
-234.922	SXY	-481.252	718.318	-3251.714	-2550.234
656.490	S1	28.281	-1967.510	2591.142	421.351
2614.092	S2	-7621.059	-12579.355	-10067.302	-14830.643
	EPE	1.44041E-02			
	EKE	0.0			

LOC 4	ELEMENT 98	LOC 1	LOC 2	LOC 3	LOC 4
4.3916E-01	X	4.18351E-01	4.21269E-01	3.66033E-01	3.76924E-01
1.763	Y	1.796	1.760	1.785	1.751
8378.606	SEFF	19966.534	34072.992	21273.145	35091.800
-6697.947	SXX	-20109.038	-36109.278	-17469.129	-32994.802
-1501.794	SYY	-643.148	-5705.463	-3836.520	-9472.976
6593.036	SXY	-1506.487	-3191.483	-8158.391	-11039.311
119.118	S1	-527.249	-5374.066	-21.675	-5103.623
-8318.860	S2	-20224.937	-36440.675	-21283.975	-37364.154
	EPE	6.76099E-02			
	EKE	0.0			

APPLICON IFAD VERSION 2.0 26-FEB-85 11.07
PROBLEM NAME = USER:[GERALD]ZTECHMOD;
STERSS ANALYSIS- BRIDGE EXPANSION JOINT - MODEL ZT2A - LEVEL=1/8 IN.

OUTPUT FOR LOAD CASE 1
LOAD SET 1

PLANE STRESS -- 4 NODED, ISOPARAMETRIC QUADRILATERAL

ELEMENT 117	LOC 1	LOC 2	LOC 3	LOC 4	ELEMENT 118
X	9.74281E-02	1.31346E-01	8.15278E-02	1.17032E-01	X
Y	1.672	1.661	1.592	1.589	Y
SEFF	7948.124	8616.468	5339.474	5749.502	SEFF
SXX	-7107.581	-7922.803	-5087.849	-5679.310	SXX
SYY	-412.695	-2110.125	-419.928	-2118.161	SYY
SXY	-2267.003	-2812.957	-1236.118	-1667.863	SXY
S1	282.718	-971.772	-112.798	-1459.020	S1
S2	-7802.993	-9061.156	-5394.980	-6338.451	S2
EPE	6.81607E-03				EPE
EKE	0.0				EKE

ELEMENT 119	LOC 1	LOC 2	LOC 3	LOC 4	ELEMENT 120
X	8.97129E-01	8.68670E-01	8.07465E-01	7.86632E-01	X
Y	1.808	1.787	1.897	1.869	Y
SEFF	2941.475	1053.414	7943.637	7298.754	SEFF
SXX	-598.055	700.761	382.222	1772.161	SXX
SYY	-2733.408	-505.119	-7739.584	-5976.625	SYY
SXY	905.136	56.279	-178.761	-1128.372	SXY
S1	-266.016	703.382	386.154	1933.130	S1
S2	-3065.447	-507.740	-7743.517	-6137.594	S2
EPE	5.05649E-03				EPE
EKE	0.0				EKE

ELEMENT 121	LOC 1	LOC 2	LOC 3	LOC 4	ELEMENT 122
X	5.36085E-01	5.36085E-01	4.63916E-01	4.63916E-01	X
Y	1.987	1.951	1.987	1.951	Y
SEFF	25497.424	14889.093	28613.714	20109.110	SEFF
SXX	28080.970	16096.829	27664.320	15680.179	SXX
SYY	6530.522	2935.276	5141.687	1546.442	SYY
SXY	878.145	635.076	-7510.756	-7753.823	SXY
S1	28116.694	16127.402	29939.203	19104.373	S1
S2	6494.798	2904.703	2866.804	-1877.752	S2
EPE	6.58713E-02				EPE
EKE	0.0				EKE